Advanced Science Reasoning Video Problems

Data Representation Problem Sets

Problem Set 1

Metabolic reactions, pain thresholds, and allergic responses are physiological functions in humans that follow a 24 hour cycle. Figure 1 displays the threshold to tooth pain in humans for two different stimuli: a cold stimulus (measured in seconds) and an electric current (measured in milliamperes). Time of day is presented in military time units (1200 hours equals noon; 2400 hours equals midnight).

A threshold is the limit below which a stimulus is not perceptible or does not evoke a response. The pain threshold is defined as the minimum point at which the person reports any feelings of pain.

Figure 2 presents the duration of feelings of numbness to tooth pain (in hours) after a set amount of anesthetic.

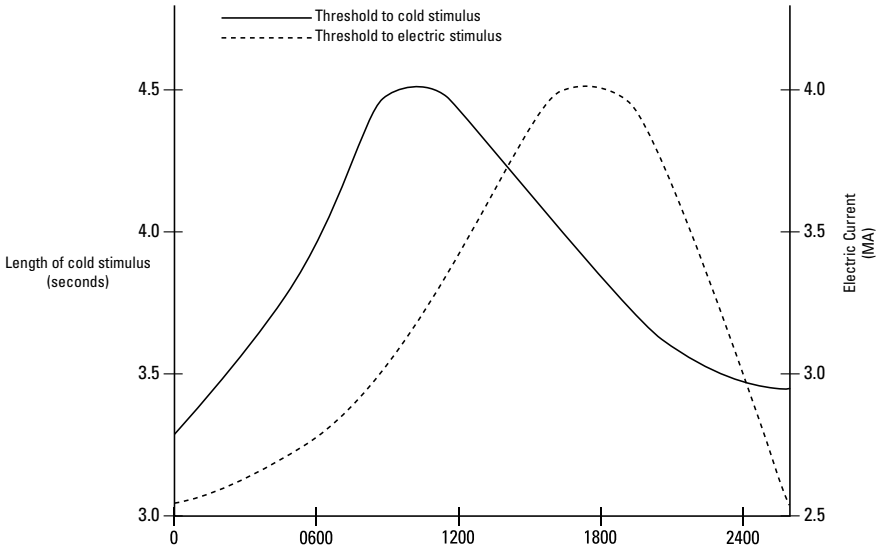


FIGURE 1

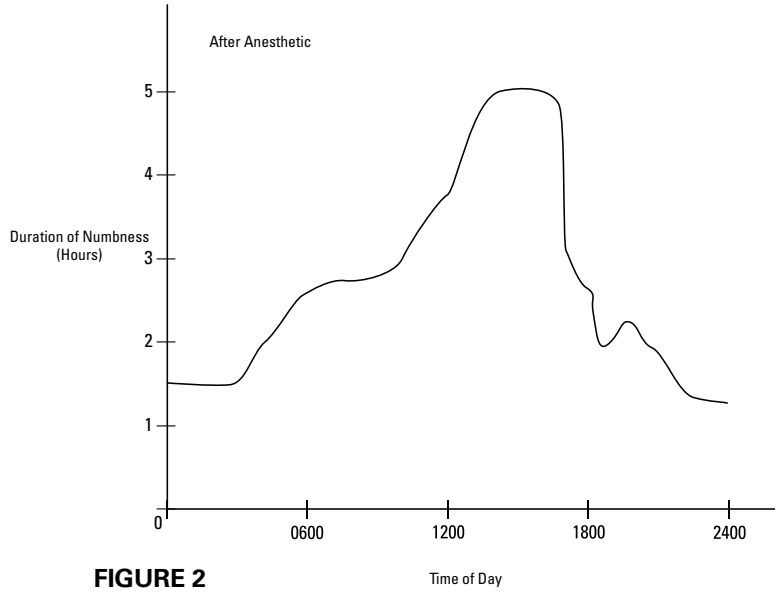


FIGURE 2

1. At approximately 1000 hours, feelings of pain would be reported to a cold stimulus after how many seconds?

   A. 3.0
   B. 3.5
   C. 4.0
   D. 4.5

2. The information in Figure 1 suggests that the lowest pain thresholds to an electric current occur:

   F. between 0600 and 1200 hours.
   G. between 1200 and 1800 hours.
   H. between 1800 and 2000 hours.
   J. between 2200 and 0400 hours.

3. The data in Figures 1 and 2 support which of the following conclusions?

   A. Pain thresholds increase throughout the day.
   B. Pain thresholds decrease throughout the day.
   C. Pain thresholds increase and then decrease throughout the day.
   D. Pain thresholds remain constant throughout the day.

4. An anesthetic is administered for tooth pain at 1500 hours. A person would report that the feelings of numbness have ended at approximately what hour?

   F. 1800
   G. 1900
   H. 2000
   J. 2100

5. The maximum pain thresholds for a cold stimulus and an electric current differ by approximately how many hours?

   A. 4
   B. 6
   C. 8
   D. 10

6. Is the hypothesis "All pain thresholds follow the same 24 hour cycle" supported by the information in Figures 1 and 2?

   F. Yes, because both figures show increases and decreases throughout the day.
   G. Yes, because pain thresholds are at a maximum between 1000 and 1600 hours.
   H. No, because the maximum pain thresholds occur at different times for different stimuli.
   J. No, because anesthetic lasts a minimum of one hour.

7. An anesthetic administered for tooth pain produced feelings of numbness for approximately two hours. When was the anesthetic most likely administered?

   A. 0300
   B. 1000
   C. 1300
   D. 1800

Problem Set 2

The electrical resistivity of copper alloys was investigated as a function of temperature. Copper was alloyed with either gold, nickel, or palladium, with varying percentages of copper contributing to the alloy. The alloy was then subjected to various temperature levels and the resistivity, in 10^{-8} ohms per meter, was measured. The data are presented in Table 1.

TABLE 1

	Temperature				
	273K	293K	300K	350K	400K
Alloys (% Copper)					
99%					
Copper-Gold	1.73	1.86	1.91	2.24	2.58
Copper-Nickel	2.71	2.85	2.91	3.27	3.62
Copper-Palladium	2.10	2.23	2.27	2.59	2.92
90%					
Copper-Gold	3.29	4.42	3.46	3.79	4.12
Copper-Nickel	13.69	13.89	13.96	14.44	14.81
Copper-Palladium	6.89	7.03	7.08	7.41	7.74
80%					
Copper-Gold	5.15	5.28	5.32	5.65	5.99
Copper-Nickel	25.46	25.66	25.72	26.12	26.44
Copper-Palladium	11.99	12.12	12.16	12.51	12.87
70%					
Copper-Gold	7.12	7.25	7.30	7.64	7.99
Copper-Nickel	36.67	36.12	36.76	36.86	36.89
Copper-Palladium	16.87	17.01	17.06	17.41	17.78

8. A 90% Copper alloy has a resistivity of 7.08. What metal was the Copper alloyed with and at what temperature was the resistivity measured?

   F. Gold at a temperature of 293K
   G. Nickel at a temperature of 300K
   H. Palladium at a temperature of 300K
   J. Palladium at a temperature of 400 K

9. Which of the following generalizations about the relationship between temperature and electrical resistivity is supported by the data in Table 1?

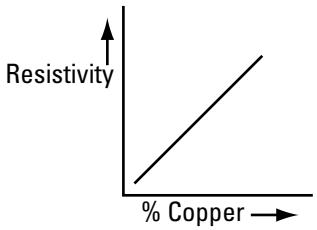
   A. As temperature increases, electrical resistivity increases.
   B. As temperature increases, electrical resistivity decreases.
   C. As temperature increases, electrical resistivity remains constant.
   D. There is no relationship between temperature and electrical resistivity.

10. The electrical resistivity of a 70% Copper-Nickel alloy at 273K is approximately how many times greater than the electrical resistivity of a 99% Copper-Nickel alloy at 300K?

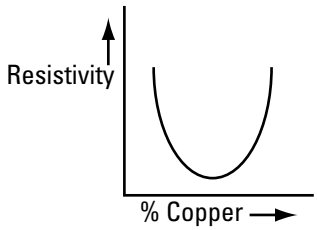
    F. 6
    G. 10
    H. 12
    J. 33

11. Which of the following graphs expresses the relationship between electrical resistivity and the percent of Copper in an alloy for a Copper-Gold alloy at 273K?

A.



B.



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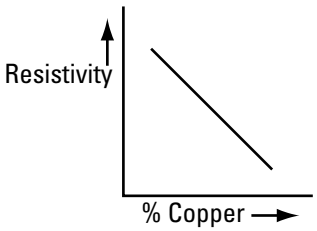
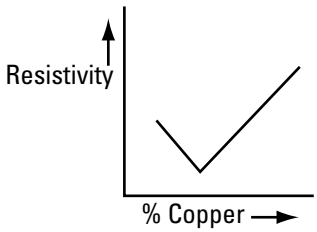


D.



12. At a temperature of 293K, what metal alloyed with 80% Copper would produce a resistivity closest to the resistivity of a 90% Copper-Nickel alloy at 273K?

F. Palladium
G. Nickel
H. Gold
J. Both Palladium and Gold

13. A Copper-Palladium alloy with an unknown percentage of Copper was tested at 375K and found to have an electrical resistivity of 17.56. The percentage of Copper in this alloy is probably:

A. 70%.
B. 80%.
C. 90%.
D. 99%.

14. An unknown alloy is composed of at least 70% Copper. At temperatures between 273K and 400K, the electrical resistivity reaches levels no lower than 9.00. Based on the information in the table, which of the following metals could be this unknown alloy with Copper?

I. Gold
II. Nickel
III. Palladium

F. I only
G. II only
H. II and III only
J. I, II, and III

Problem Set 3

Factors related to the absorption of sound in still air are presented in Table 1. The absorption rate (measured in decibels per 1000 feet) is measured for sound waves of varying frequencies (measured in Hz) and in still air with different relative humidities. Humidity is a measure of the amount of moisture in the air. Table 2 presents the speed of sound in various media. The velocity of sound is measured in meters per second (m/s) and the densities of the various media are measured in appropriate units.

TABLE 1
Relative humidity

Frequency	0%	5%	10%	20%	30%
20	.154	.031	.021	.013	.009
40	.327	.074	.064	.045	.034
50	.384	.092	.084	.066	.051
100	.509	.179	.161	.159	.075
200	.560	.449	.289	.285	.275
4000	2.696	22.685	31.023	18.991	11.856

TABLE 2

Gases	Speed of Sound (m/s)	Density (g/L)
Air (0°C)	331	1.293
Hydrogen	1284	0.090
Oxygen	316	1.429
Helium	965	0.178
Liquids at 25°C	**Speed of Sound (m/s)**	**Density (g/cm^3)**
Water	1490	0.998
Kerosene	1324	0.810
Seawater	1530	1.025
Solids	**Speed of Sound (m/s)**	**Density (g/cm^3)**
Aluminum	5000	2.700
Copper	3810	8.930
Gold	5120	19.700
Lead	1210	11.400

15. At a frequency of 40 Hz, the absorption rate of sound was measured as 0.03 decibels per 1000 feet. Most likely, what was the percentage of moisture in the air at the time this measurement was taken?

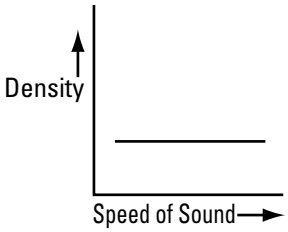
A. 5%
B. 10%
C. 20%
D. 30%

16. For frequencies between 20 and 100 Hz, which of the following expresses the relationship between humidity and absorption rate?

F. As humidity increases, absorption rate increases.
G. As humidity increases, absorption rate decreases.
H. As humidity increases, absorption rate remains constant.
J. As humidity increases, absorption rate increases and then decreases.

17. The relationship between speed of sound and density for the gases described in Table 2 can best be graphed as which of the following?

A.



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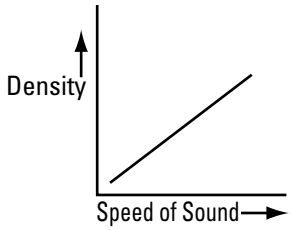
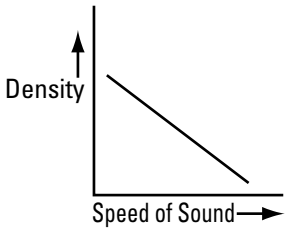
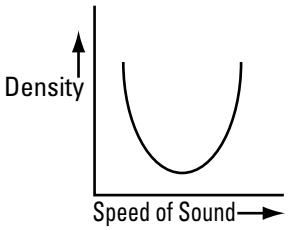


C.



D.



18. The relationship between speed of sound and density for the solids listed in Table 2 can best be described as which of the following?

F. As density increases, speed of sound increases.
G. As density increases, speed of sound decreases.
H. As density increases, speed of sound remains constant.
J. There is no apparent linear relationship between density and speed of sound.

19. Would the hypothesis "Absorption rate decreases as humidity increases" be supported by the data in Table 1?

A. Yes, because this pattern describe sound at all the frequencies listed.
B. Yes, because at a frequency of 100 Hz, absorption rates decrease.
C. No, because the value of absorption rates differ for different frequencies.
D. No, because at a frequency of 4000 Hz, absorption rates initially increase.

20. The hypothesis "Speed of sound increases as density decreases" is supported by data related to which of the following media?

I. Gases
II. Liquids
III. Solids

F. I only
G. I and II only
H. II and III only
J. I, II, and III

Problem Set 4

Researchers hypothesized that the survival rate of certain species of moths would be influenced by various environmental conditions. Furthermore, they hypothesized that certain characteristics of moth species would allow them to adapt to specific environmental conditions and the survival rate of these species would depend on these adaptations. Those moths with successful adaptations would evidence low levels of predation (that is, high numbers of moths would survive). A series of experiments was designed to test these hypotheses.

Experiment 1

Two sites were chosen which differed in industrial pollution levels. Site One had a low rate of pollution; consequently, most tree trunks were close to their natural color. Site Two had a high rate of pollution as measured by various indices; at this site, most of the tree trunks were blackened. A large number of pale moths and black moths were captured from other sites and tagged for identification. Equal numbers of pale and black moths were released at both sites. Two weeks later researchers recaptured as many moths as possible at both sites. The percentage of recaptured rates indicated the rate of predation. The data for this experiment are displayed in Table 1.

TABLE 1

Location	Pollution Level	% Pale Moths Recaptured	%Black Moths Recaptured
Site One	Low	13.2	6.3
Site Two	High	13.1	27.5

Experiment 2

To investigate the effects of predator level, the experiment was repeated at four different locations. Two of the sites were judged to contain a low number of predators that typically fed on moths, while another two of the sites were judged as having a high number of predators that typically fed on moths. Otherwise the experimental procedures were as in Experiment 1. The data for this experiment are displayed in Table 2.

TABLE 2

Location	Predator Level	Pollution Level	% Pale Moths Recaptured	% Black Moths Recaptured
Site Three	Low	Low	14.1	7.5
Site Four	High	Low	5.3	2.7
Site Five	Low	High	12.7	25.2
Site Six	High	High	4.3	8.5

21. Experiment 2 differs in its experimental design from Experiment 1 in that Experiment 2:

    A. used a different procedure to recapture moths.
    B. hypothesized that a variable other than pollution level was influencing moth survival rates.
    C. increased the number of pollution levels studied.
    D. had lower percentages of moths recaptured.

22. Which of the following conclusions is supported by the data in Experiment 2?

F. Only pollution levels affect the percentage of black moths recaptured
G. Only predator levels affect the percentage of black moths recaptured
H. Both predator and pollution levels affect the percentage of black moths recaptured
J. At all levels studied, more pale moths are recaptured than black moths

23. The highest percentage of pale moths that did not survive in Experiment 2 would be found at which of the following sites?

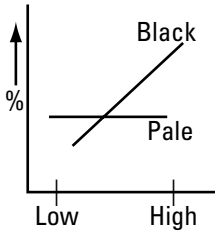
A. Site Three
B. Site Four
C. Site Five
D. Site Six

24. Which of the following conclusions concerning pale moths is supported by the data in the two experiments?

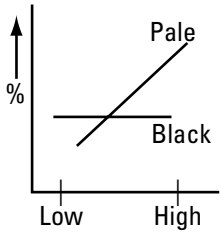
F. Holding pollution level constant, higher predator levels reduce the number of pale moths recaptured
G. Pale moths adapt to all pollution levels better than black moths
H. Lower percentages of pale moths survive in all conditions
J. Fewer moths are recaptured at higher pollution levels

25. Which of the following graphs expresses the relationship between pollution level and the percent of pale and black moths recaptured in Experiment 1?

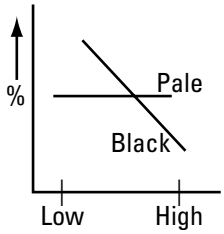
A.



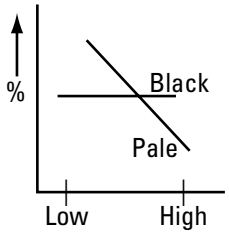
B.



C.



D.



26. In Experiment 2, the percentage of pale moths recaptured in conditions in which the pollution level was high and the predator level was low is approximately one-half the percentage of black moths recaptured under which of the following conditions?

F. Low pollution levels and low predator levels
G. Low pollution levels and high predator levels
H. High pollution levels and low predator levels
J. High pollution levels and high predator levels

27. At what site would the lowest level of predation among black moths be found?

A. Site Six
B. Site Five
C. Site Four
D. Site Three

Problem Set 5

Researchers investigated factors that affect osteoporosis in adult women. Osteoporosis is a bone disease in which the bone mineral density decreases to such low levels that bones may be susceptible to fractures.

Experiment 1

The average bone mineral density (BMD) was measured for samples of women at various ages. The fracture threshold is the point below which the likelihood of a bone fracture increases, given the application of moderate stress. Data for this experiment are graphed in Figure 1.

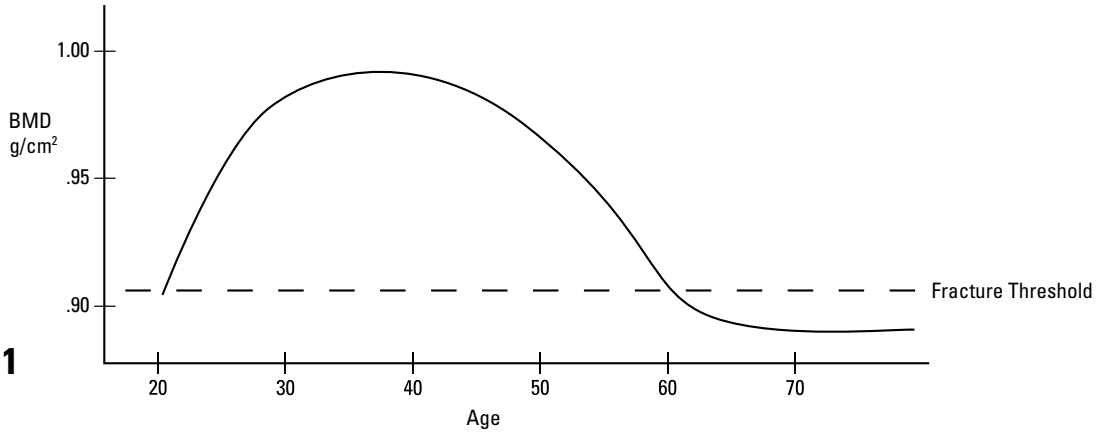


FIGURE 1

Experiment 2

Two groups of women, fifty years of age or older, participated in a study to determine the effects of exercise on changes in BMD. The Exercise Group participated in controlled aerobic exercises for a period of one hour, three times a week, for twelve months. The Control Group did not participate in controlled exercises. The percent change in BMD was measured at monthly intervals, using 100% as the baseline measure. The data are graphed in Figure 2.

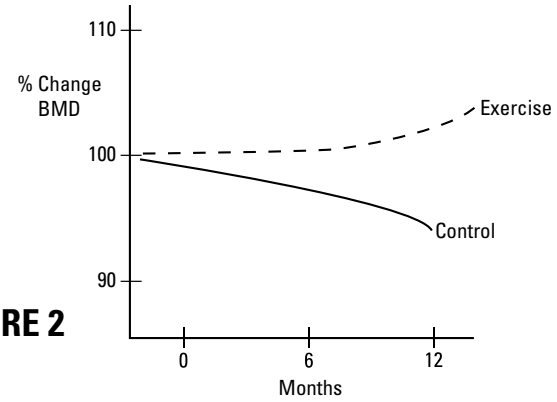


FIGURE 2

Experiment 3

The BMD levels for a group of female athletes, aged 50 or older, was measured over a six month period. These women exercised an average of 7.5 hours per week in moderate to heavy aerobic exercises. The percent of BMD decreased over the six month period. These results are similar to studies done with younger male athletes.

28. Based on the data in Experiment 1, the maximum difference in bone mineral density between younger women and older women is approximately:

F. .90 g/cm^2.
G. .50 g/cm^2.
H. .25 g/cm^2.
J. .09 g/cm^2.

29. Which of the following conclusions is supported by the control group results in Experiment 2?

    A. The amount of BMD remained constant
    B. The amount of BMD decreased
    C. The amount of BMD increased
    D. Levels of BMD are not affected by exercise

30. A woman's BMD measurement is 0.88 g/cm^2. Most likely, how old is the woman according to data from Experiment 1?

    F. 27
    G. 44
    H. 52
    J. 63

31. Over the past twelve months, a sixty-year-old woman has exercised moderately for approximately nine hours per week. According to the data from these experiments, it is likely that:

    A. her BMD level has increased.
    B. her BMD level has decreased.
    C. her BMD level has remained constant.
    D. there is not enough information to determine a change in BMD level.

32. Suppose that the average BMD of the two groups of women in Experiment 2 was .90 g/cm^2 at the beginning of the study. Which of the following conclusions would be supported by the results of Experiment 2?

    F. The levels of BMD in the Control group would remain constant
    G. The levels of BMD in the Control group would increase
    H. Controlled exercise could increase BMD to a level above the fracture threshold
    J. Controlled exercise could not increase BMD to a level above the fracture threshold

33. Is the statement "Increases in the amount of weekly exercise will lead to increases in BMD" supported by the results in all three experiments?

    A. Yes, because the Exercise Group in Experiment 2 increased its BMD levels
    B. Yes, because levels of BMD increased for all women who participated in weekly exercise
    C. No, because levels of BMD decrease as a function of age
    D. No, because the women in Experiment 3 showed decreases in BMD at higher exercise levels

34. The researchers hypothesized that changes in both exercise and diet would increase the BMD of women over 50. Specifically, they felt that the addition of a dietary supplement, such as calcium, would increase BMD levels. Which of the following changes in experimental design would best test this hypothesis?

    F. Modify Experiment 2 to include Exercise and Control groups that did and did not take calcium supplements
    G. Modify Experiment 1 to include BMD levels for men at different ages
    H. Modify Experiment 3 to includes groups of men and women who take calcium but don't exercise
    J. Chart the average levels of calcium uptake in men at different ages

Problem Set 6

Changes in altitude can produce various changes to the muscular, cardiovascular, and respiratory system in humans. Several experiments were conducted to determine how changes in altitude affect human performance.

Experiment 1

Sudden exposure to certain altitudes can produce a rapid loss of consciousness in humans. This is particularly apparent in people who had not been acclimatized; that is, people who had not been given time to adjust to the higher altitude. The effect of sudden exposure to various altitudes on unacclimatized subjects was measured and the results presented in Figure 1.

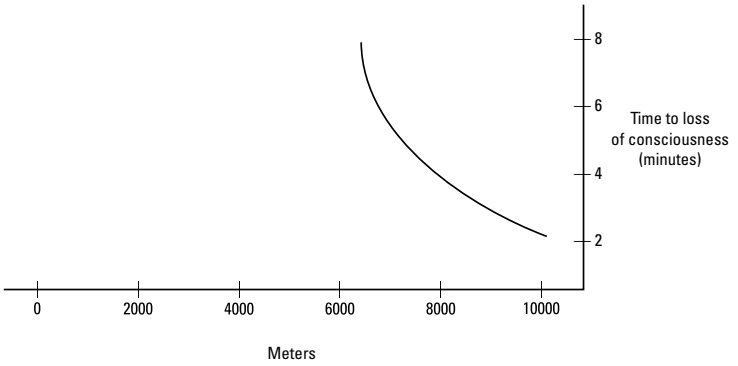


FIGURE 1

Experiment 2

The heart rate at different work rates was measured for one subject at both sea level and at an altitude of 5800 meters. The subject had a period of two weeks to be acclimatized at the 5800 meter altitude before the experiment began. The results are presented in Figure 2.

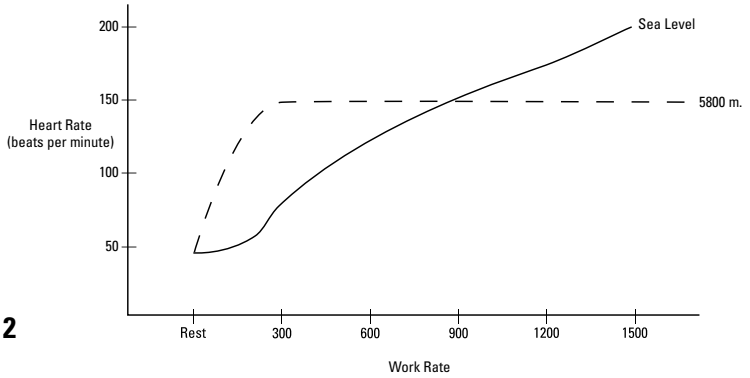


FIGURE 2

Experiment 3

The effects of altitude on the speed of athletic performance was tested. Athletes were timed running at five different intervals (100 meters to 1500 meters) and at five different altitudes (sea level to 4000 meters). The percent increase or decrease in athletic speed was measured relative to sea level performance. The data are presented in Table 1.

TABLE 1
Distance (m)

Altitude (m)	100	200	400	800	1500
Sea Level	100	100	100	100	100
1000	101	101.5	100.5	99.5	97
2000	101.5	102.1	101	98	95
3000	102	102.7	100.5	97.2	92.5
4000	103.5	103.5	100.1	93.5	89.5

35. A person suddenly exposed to an altitude of 8000 meters would lose consciousness in approximately how many minutes?

A. 2
B. 4
C. 6
D. 8

36. At an altitude of 2000 meters above sea level, an athlete's performance running 200 meters would be closest to his or her performance running what distance at an altitude of 3000 meters above sea level?

F. 100
G. 200
H. 400
J. 800

37. At a work rate of 1200, an individual's heart beats 175 times per minute. At what altitude was this measurement probably taken, based on the information in the experiments?

A. Sea level
B. 5800 meters above sea level
C. 8000 meters above sea level
D. 9700 meters above sea level

38. Which of the following conclusions is supported by the results of Experiment 2 concerning human performance at an altitude of 5800 meters?

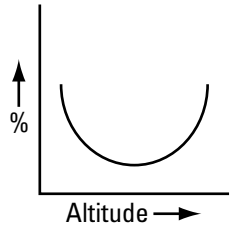
F. As work rate increases, heart rates first increase and then become constant
G. As work rate increases, heart rates increase
H. As work rate increases, heart rates decrease
J. As work rate increases, heart rates first decrease and then become constant

39. From Experiment 2, the heart rate at a work rate of 300 for the subject at an altitude of 5800 meters is equivalent to what work rate at sea level?

A. 300
B. 600
C. 900
D. 1200

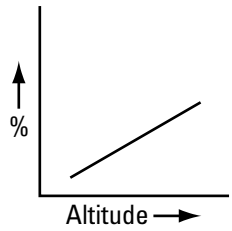
40. Which of the following graphs expresses the relationship between altitude and percent change in athletic performance for runners at a distance of 800 meters?

F.

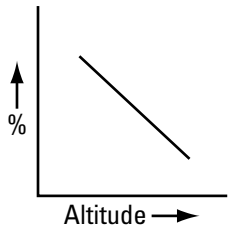


G.

H.



J.



41. Which of the following conclusions is supported by the results of Experiment 3?

A. As altitude increases, athletic performance increases at all distances
B. As altitude increases, athletic performance decreases at all distances
C. As altitude increases, athletic performance decreases at short distances and increases at long distances
D. As altitude increases, athletic performance increases at short distances and decreases at longer distances

42. At an altitude of 2000 meters, an athlete running a distance of 900 meters would probably notice what percent change in his or her athletic performance (relative to sea level)?

F. 3% increase
G. 3% decrease
H. 5% increase
J. 5% decrease

Conflicting Viewpoints
Problem Set 7

Over 15 million years ago, an asteroid hit the Martian surface, flinging rocks into space. One particular meteorite, ALH84001, fell on Antarctica 13,000 years ago and was discovered recently by geologists. The meteorite has undergone extensive testing for signs of possible life. Two scientists discuss the possibility that there is evidence of life to be found in this sample of rock from the planet Mars.

Scientist 1

[1] There are several pieces of evidence which support the conclusion that ALH84001 contains signs of microbial life. [2] First, the rock contains tiny globules of carbonates, probably formed when carbon-rich water (a prerequisite for life) flowed through the rock. [3] Second, the rims of the globules are coated with iron sulfide and other minerals which can be produced by bacteria. [4] Third, the globules contain what appear to be nanofossils, tiny elongated and ovoid forms resembling fossils left by bacteria on Earth. [5] Finally, the rock compounds contain polycyclic aromatic hydrocarbons, or PAHs, which often have biological origins. [6] The concentration of PAHs increased as the interior of the meteorite was analyzed. [7] If the PAHs were due to earthly contaminants, then their concentration should have been largest at the surface.

[8] Studies from sites on Earth have found concentrations of microfossils and tiny bacteria identical to those found in the meteor. [9] These specimens were discovered in harsh environments, suggesting that the life forms in this meteorite could have survived in similar circumstances. [10] The development of new technology, which could detect preserved microbial cell walls in the fossils, should lend support to this argument.

Scientist 2

[11] There is no conclusive evidence that signs of life on Mars are found on the meteorite ALH84001. The meteorite has probably been contaminated by earthly substances. [12] For instance, PAHs are associated with coal and diesel exhaust, contaminants which could have affected the meteorite. [13] PAHs are also abundant in ancient sedimentary rocks and the residue of chemical changes that occurred to dead marine plankton and plant life that were the source of these rocks. [14] The same PAHs are found in meteorites that did not come from other planets and which were formed too early in the history of the solar system for life to have come into existence. [15] Furthermore, the supposed fossils have internal structures that more closely resemble crystals of iron oxide rather than small bacteria found on Earth. [16] The minerals in the meteorite were formed at temperatures as high as 1,400 degrees Fahrenheit, circumstances much too hot to have supported biological processes. [17] Even if new technology indicates the presence of cell walls, it will be difficult to determine whether the bacteria came from Mars or were formed after the meteorite fell to Earth.

43. The statement "When tested, many meteorites from other planets contain minerals of earthly origin" would support:

    A. Scientist 1, because these minerals contain iron oxide.
    B. Scientist 1, because these meteorites came from Mars.
    C. Scientist 2, because these minerals contain nanofossils.
    D. Scientist 2, because these results indicate that meteorites can be contaminated.

44. Which of the following pieces of evidence would not support Scientist 1's theory?

    F. New testing which revealed that the concentration of PAHs was largest on the surface of ALH84001
    G. The discovery of nanofossils on other Martian meteorites
    H. The existence of bacteria at temperatures over 1400 degrees Fahrenheit
    J. New testing which revealed a higher percentage of carbonates in ALH84001

45. Which of the following pieces of evidence would not support Scientist 2's theory?

A. The discovery of residues of diesel exhaust in the area of Antarctica where the fossil was found
B. The absence of signs of plant life in the area of Antarctica where the fossil was found
C. The discovery that nanofossils are strictly of earthly origin
D. The presence of higher levels of iron oxide in ALH84001

46. Both scientists assume which of the following?

F. All meteorites contain evidence of bacteria
G. PAHs are only produced by biological processes
H. Technology can accurately determine the composition of meteorites
J. The presence of nanofossils is evidence of extraterrestrial life

47. Scientist 1 and Scientist 2 would agree on which of the following points?

A. Earthly contaminants are rarely found in meteorites
B. Bacteria can survive in high temperature environments
C. Nanofossils resemble the structures of iron oxide
D. PAHs can have biological origins

48. Scientist 1 and Scientist 2 would disagree on which of the following points?

F. Meteorites can be contaminated
G. The extreme conditions under which biological processes can be supported
H. Some meteorites could contain evidence of extraterrestrial life
J. PAHs are found in meteorites that did come from other planets